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INTERNATIONAL ENGINEERING CO INC SAN FRANCISCO CA F/6 13/13
NATIONAL DAM SAFETY PROGRAM, DRESSER NUMBER 10 DAM (MO 31153), --ETC(U)
JUN 79 K B KING, M P FORREST, D R SANDERS DACW43-79-C-0037

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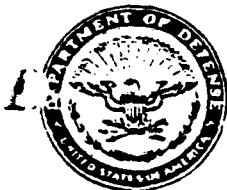
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Dresser No. 10 Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Dresser No. 10 dam:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District because the spillway can pass only 30 percent of the Probable Maximum Flood without excessive spillway erosion and possible failure of the dam. Also, the dam has excessively steep downstream embankment slopes.

SUBMITTED BY: SIGNED
Chief, Engineering Division

21 SEP 1979

Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

21 SEP 1979

Date

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DRESSER NO. 10 DAM
JEFFERSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31153

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
INTERNATIONAL ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
SAN FRANCISCO, CALIFORNIA

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

JUNE 1979

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Dresser No. 10 Dam
State	Missouri
County	Jefferson
Stream	Tributary to Big River
Date of Inspection	23 March 1979

Dresser No. 10 Dam was inspected by a civil engineer and an engineering geologist from International Engineering Company, Inc. of San Francisco, California. This dam is owned by Dresser Minerals Division of Potosi, Missouri. The purpose of the inspection was to assess the general condition of the dam with respect to safety. The assessment was based on an evaluation of the available data, a visual inspection, and an evaluation of the hydrology and hydraulics of the site to determine if the dam poses hazards to human life or property. The purpose of the dam is to impound tailings from a barite separation and beneficiation operation.

Dresser No. 10 Dam was inspected using the "Recommended Guidelines for Safety Inspection of Dams" furnished by the Department of the Army, Office of the Chief of Engineers. Based on these Guidelines, this dam is classified as large. The U.S. Corps of Engineers has classified it as having a high downstream hazard potential to indicate that failure of this dam could threaten life and property. The damage zone, estimated by the U.S. Corps of Engineers, extends about 4 miles downstream of the dam. There are several dwellings, two bridges, and a highway within this damage zone.

The results of the inspection and evaluation indicate that the spillway does not meet the criteria given in the Guidelines for a dam with the size and hazard potential of Dresser No. 10 Dam. As a large dam with a high hazard potential, it is required by the Guidelines to pass the Probable Maximum Flood (PMF) without overtopping the crest. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. It was calculated that the spillway could pass a 100-year flood (a flood having a 1 percent chance of being equalled or exceeded in any 1 year) without overtopping the dam. It was also estimated that the spillway could pass 30 percent of the PMF without significant erosion of the spillway or embankment. However, the spillway cannot pass 50 percent of the PMF without significant erosion of the spillway and embankment.

The existing spillway terminates on the left abutment hillside above the natural drainage. The spillway should be extended to the natural drainage channel. The spillway should also be constructed

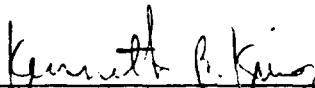
and/or the freeboard increased so that the PMF can be passed without overtopping the dam and without significant erosion of the embankment and spillway channel.

The soils immediately downstream of the dam on the left abutment were soft and saturated. Seepage was observed in that area of the dam-site. This soft soil condition and the steep downstream slope of the dam could adversely affect the stability of the structure.


Seepage and stability analyses of the dam are not available. These studies should be performed by a professional engineer experienced in the design and construction of tailings dams. The necessary data for these analyses would be obtained from additional investigations. The investigation would consist of field exploration and soil sampling, a laboratory testing program, and an engineering study to evaluate the stability of the dam.

An inspection and maintenance program should be initiated. Periodic inspections should be made and documented by qualified personnel to observe the performance of the dam and spillway.

It is recommended that the owner take action to correct the deficiencies described.


Kenneth B. King, P.E.


Michael P. Forrest, P.E.


for Donald R. Sanders, R.G.



OVERVIEW OF DRESSER NO. 10 DAM
FROM RIGHT ABUTMENT

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DRESSER NO. 10 DAM
ID NO. 31153

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APPENDIX A
HYDROLOGIC AND HYDRAULIC ANALYSES

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- | | |
|---|--|
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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DRESSER NO. 10 DAM - ID NO. 31153

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Dresser No. 10 Dam be made and authorized International Engineering Company, Inc. to make the inspection.

b. Purpose of Inspection. The purpose of the inspection was to assess the general condition of the dam with respect to safety, based on available data and visual inspection, to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These Guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

- (1) Dresser No. 10 Dam is an earthfill dam that is used to impound tailings from a barite separation and beneficiation operation. The dam is being continually raised to provide storage for tailings. The tailings consist of reddish-brown soft silty clay, which is being deposited as a slurry in a water environment.
- (2) The spillway, located on the left abutment, consists of an open channel cut into natural clayey soil. The spillway, roughly trapezoidal in cross-section, is 14 feet wide at the bottom and has a maximum depth of about 5.5 feet.

b. Location. The dam is located in the southern portion of Jefferson County, Missouri, as shown in Plate 1. The dam (shown in Plate 2) is located in Section 17, Township 38 North, Range 4 East.

c. Size Classification. This dam is greater than 100 feet high and is therefore in the large size classification, according to the "Recommended Guidelines for Safety Inspection of Dams."

d. Hazard Classification. The U.S. Corps of Engineers has classified this dam in the high hazard potential category. The estimated damage zone, as provided by the Corps of Engineers, extends about 4 miles downstream of the dam. There are several dwellings, two bridges, and a highway within this distance.

e. Ownership. This dam is owned by:
Dresser Minerals Division
Dresser Industries, Inc.
P. O. Box 8
Potosi, MO 63664

f. Purpose of Dam. The purpose of the dam is to impound the tailings from a barite separation and beneficiation operation.

g. Design and Construction History. Construction of the dam began in about 1974. The dam is being continually raised to provide additional tailings storage capacity. The design and construction information is discussed in Section 2.

h. Normal Operating Procedures. The outflow of surface runoff would pass through an uncontrolled spillway located on the left abutment. Fine barite tailings are discharged in a slurry from the mill into the impoundment, near the upstream face of the dam at the right abutment. Water from the upstream end of the pond is recycled back to the mill.

1.3 PERTINENT DATA

Field surveys were made by Booker Associates, Inc. of St. Louis, Missouri. The date of the survey was 28 March 1979. Since the dam is being continually raised, the data gathered during the survey applies only to the time that the survey was made. The survey information is presented in Plates 3, 4, and 5.

a. Drainage Area. 187 Acres (Topographic Quadrangle; 7.5-minute series, Vineland, Missouri, 1960).

b. Discharge at Damsite.

- (1) Outlet pipe. There is no outlet pipe at this dam. Not applicable.
- (2) Spillway discharge for pool at top of dam (El. 705.5) -
695 cfs.

(3) Maximum experienced outflow at damsite - no available information.

c. Elevation (Feet Above M.S.L.)^{1/}

- (1) Top of dam - Varies from El. 705.5 to El. 712.5.
- (2) Streambed at downstream toe of dam - El. 606 \pm .
- (3) Spillway crest - El. 700.0.
- (4) Tailings surface adjacent to dam - Varies from El. 698.0 to El. 702.1.

d. Reservoir. Length of existing impoundment - Approximately 3000 feet (Topographic Quadrangle; 7.5 minute series, Vine-land, Mo., 1960)

e. Storage.

- (1) Spillway crest (El. 700.0) - 1118 acre-feet.
- (2) Top of dam (El. 705.5) - 1310 acre-feet.

f. Reservoir Surface Area.

- (1) Spillway crest (El. 700.0) - 36.0 acres.
- (2) Top of dam (El. 705.5) - 39.5 acres.

g. Dam.

- (1) Type - Earthfill.
- (2) Length - 765 feet \pm .
- (3) Height (maximum above streambed) - 107 feet \pm .
- (4) Top width - 40 feet \pm .

^{1/} Elevations are based on a reference datum of 740.00 M.S.L. at the temporary bench mark (see Plate 3). This elevation was estimated from the topographic quadrangle.

(5) Side slopes -

- (a) Downstream: 1.5 (H) to 1.0 (V).
- (b) Upstream: Unknown.

(6) Zoning - The zoning of the dam consists of a clay starter dam, which is overlain by sands and angular gravels. The sands and gravels are from the barite ore milling process, and the gravels are finer than 7/8-inch.

(7) Cutoff - A clay core trench to bedrock is shown on a design drawing for the starter dam.

h. Spillway.

- (1) Type - Uncontrolled open channel spillway.
- (2) Control section - 14-foot bottom width, 5.5-foot depth, 34-foot top width, and approximate side slopes of 1.5(H) : 1.0(V) and 2.2 : 1.0.
- (3) Crest elevation - El. 700.0 M.S.L.
- (4) Upstream channel - Clear.
- (5) Downstream channel - Shallow cleared section.

i. Regulating Outlets. None.

j. Diversion Ditches. None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Documentation of the design of the starter dam is shown on a drawing by Dresser Minerals dated November 17, 1975 and entitled "No. 10 Starter Dam, Plan and Sections, St. Francis County, Mo.", (no drawing number). This drawing was in the Dresser Minerals office near Mineral Point, Missouri. The drawing indicated the following data for the starter dam:

Downstream slope - 2 (H) to 1 (V)
Crest width - 40 feet
Maximum section - 41 feet
Spillway channel - 14 feet wide

The drawing also depicted a cutoff trench of unknown depth.

Spillway channel hydraulic computations and runoff calculations are shown in a record by Dresser Minerals entitled "Spillway for Dam at Washer No. 10", dated November 18, 1975. These computations were available at the Dresser Minerals office, Mineral Point, Missouri. Watershed runoff was computed as follows:

where, $Q = Aci$,
 $A = 200$ acres
 $c = 0.5$
 $i = 3.5$ in/hr.

therefore, $Q = 200 \times 0.5 \times 3.5 = 350$ cfs.

The discharge capacity of the spillway was calculated by Dresser Minerals using Manning's Equation to equal 351.3 cfs for a 14-foot wide channel flowing 3 feet deep with side slopes of 2 (H) to 1 (V) on one side and 1 to 1 on the other side.

2.2 CONSTRUCTION

No construction records were available. Mr. A. E. Williams, a representative of Dresser Minerals, indicated that construction of Dam No. 10 was begun in 1974. The representative stated that the damsite was cleared of vegetation before the clay starter dam was constructed. After construction of the starter dam, sand and angular gravels (finer than 7/8-inch) from the No. 10 mill were hauled to the crest of the dam by truck, end-dumped and spread by dozer or grader. Excess material was pushed over the upstream and downstream faces of the dam. The sands and gravels placed in this manner are in a loose state and are at their natural angle of repose on the downstream face. The material pushed over

the upstream side rests on the tailings. The centerline of the dam remains approximately at the same position as the embankment is raised. Compaction of the material on the crest is by construction equipment. Presently, the construction is proceeding in the same manner.

A report by J. H. Williams of the Missouri Geological Survey dated 30 September 1975 and entitled "Engineering Geologic Report on Dresser No. 10 Barite Pond", indicates that sliding occurred in the starter dam. The report also indicates that the starter dam had been leaking severely, particularly in the left portion of the dam. This report is in Appendix B.

The representative from Dresser also indicated that a spring was located on the right abutment hillside, downstream of the starter dam and above the natural stream channel. The representative indicated that a 12-inch diameter steel pipe was constructed from the spring to a discharge point downstream in the natural stream channel. The length of this pipe is not known. The pipe was set in concrete at the spring. This spring was covered by the dam as it was expanded in the downstream direction. No construction records of the pipe installation were available.

2.3 OPERATION

No operating records are known to exist. The outflow of surface runoff would pass through an uncontrolled spillway. Barite tailings are being conveyed as a slurry to the impoundment. Water is separated from the tailings by a filtering process through a gravel dike located at the upper end of the impoundment. The water is then pumped back to the mill.

2.4 EVALUATION

a. Availability. Limited design records and construction information were available. The starter dam design and runoff/spillway calculations were prepared for documentation purposes after construction began. The only construction information available to the inspection team was a verbal communication with the owner's representative.

b. Adequacy. The field surveys and visual inspections presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and this lack of information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record.

c. Validity. Available information pertaining to the starter dam could not be confirmed by the visual inspection because the starter dam underlies the embankment sands and gravels. According to the Guidelines, the computed runoff of 350 cfs is not adequate for the dam, as indicated in Section 5 - Hydraulic and Hydrologic Analyses.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. The dam was inspected by a civil engineer and an engineering geologist from International Engineering Company, Inc. on 23 March 1979. Mr. A. E. Williams, a representative of Dresser Minerals, met with the inspection team on 21 March and 23 March 1979. The impoundment created by Dresser No. 10 Dam is currently in use as a barite tailings storage site. The dam is being continually raised to provide additional tailings storage capacity. Photographs taken during the inspection are included in this report. The field locations of the photographs are shown in Plate 6.

b. Project Geology. The reservoir watershed is covered by a residual reddish-brown sandy clay that contains irregular masses of barite, chert, and quartz druse. Soil cover appears to be generally less than 5 feet thick but can be 10 feet or more in some areas. The underlying bedrock consists of massive dolomite of late Cambrian age.

Natural outcroppings of dolomite bedrock occur as nearly vertical cliffs about 100 feet high along the east side of the Big River about 300 feet west of the left abutment of the dam. Bedrock has been exposed by excavation immediately downstream of the dam on the right abutment hillside. The bedrock surface is highly irregular and contains numerous small solution cavities and pinnacles of resistant druse. Dolomite exposures were also observed in the natural stream channel downstream of the dam. Both dam abutments are covered with reddish-brown clayey soil with gravel and rock fragments. The soil downstream of the dam appears to be reddish-brown silty clay.

c. Dam. The plan of the dam is shown in Plate 3. The profile and cross-sections of the dam and spillway are shown in Plates 4 and 5.

There is no vegetation on the embankment itself. Some grass cover exists on the natural soils downstream of the dam.

No detrimental settlement, depressions, sinkholes, animal burrows, or cracks were observed; however, it is doubtful such features would be apparent because of the continual addition of new gravel fill. Minor erosion of the northern end of the upstream face of the dam was observed. The mill discharge has undercut a small portion of the upstream face and has caused minor sloughing of the embankment materials. This erosion is repaired by adding sand and gravel material to raise the dam.

Extensive seepage was observed along the downstream toe of the left abutment of the dam from Station 1+00 to Station 5+00 and in the area downstream of the left abutment. Throughout this area, the ground was soft and wet with water oozing from the clay soils. The seepage accumulated in many small rills with the total cumulative quantity of seepage estimated at about 10 gpm. The flow was clear and no evidence of piping was observed.

Clear water from a spring in the dam foundation was being discharged from a 12-inch diameter steel pipe that emerges in the stream channel downstream from the dam. The flow in the pipe was about 3 inches deep and was estimated to be 50 to 100 gpm.

The difference in elevation between the top of tailings and the dam crest ranged from about 7 to 12 feet on the date that the survey was made (28 March 1979). The elevation difference from the spillway crest to the low point in the dam crest was 5.5 feet on the date of the survey.

d. Appurtenant Structures. The only appurtenant structure associated with the dam is the spillway at the left abutment. The spillway consists of an unlined open channel excavated in natural soil on the left abutment hillside. The north side of the spillway channel abuts on the dam embankment. The bottom of the spillway consists of soft clayey soil. Some sloughing of the abutment (south) side of the spillway was observed near the dam axis. The spillway extends downstream about 160 feet from the centerline of the dam and curves toward the toe of the dam. Downstream of the spillway crest, the channel is shallow and does not extend to the natural stream channel. It terminates on the left abutment hillside.

e. Reservoir Area. No evidence of landsliding was observed in the reservoir area. Very little erosion was evident on slopes covered with natural woodland vegetation, which comprises about 90 percent of the watershed area above the impoundment. Erosion of slopes below the mill caused by the tailings discharge was observed, but this is confined to a small area. The tailings in the impoundment consist of soft silty clay that is being deposited by hydraulic methods. Minimal consolidation of the tailings has probably taken place. There are no upstream structures within the watershed of this dam that would be subjected to backwater flooding.

f. Downstream Channels. Discharge from the spillway channel would flow down the left abutment hillside, for a vertical distance of about 90 feet, into a small pond in the natural downstream channel. The outlet for that pond is a shallow channel about 3 feet wide and 50 feet long. This channel flows into the Big River. The width of the floodplain of the Big River ranges from 500 to 1200 feet between the dam site and the town of Blackwell, about 2 miles downstream of the dam.

3.2 EVALUATION

Minimal consolidation of the clay tailings has probably taken place, and, therefore, the dam is effectively retaining a material with very low strength. The tailings exert a high pressure that the dam must resist.

The embankment is a relatively porous granular structure above the tailings surface. If the water level were to rise above the tailings surface

due to flood runoff, there could be significant seepage through the embankment which could adversely affect the stability of the dam.

The soils located downstream of the left abutment of the dam were soft and saturated. Seepage was observed in the left abutment area of the dam. Currently, the dam is being constructed in the downstream direction over these soft foundation soils. This soft soil condition and the steep downstream embankment slope could cause potential instability of the embankment as the dam is raised.

The spillway consists of an unlined side-hill bench cut in clayey soil. The soft clay soils are subject to erosion. Sloughing of the uphill, or abutment, side of the spillway was observed. The spillway channel does not extend to the natural drainage channel downstream of the dam. During high flood flows, discharge from the spillway could erode the soil downstream of the dam and eventually undercut the toe of the dam. Since the spillway channel abuts on the dam, flood flows could also erode the embankment materials.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

No regulating procedures are known to exist for this dam. The dam is continually being raised to provide additional tailings storage capacity. Surface runoff passes through an uncontrolled spillway channel on the left abutment. Water used to transport tailings from barite separation to the impoundment is recycled back to the mill from the upstream end of the pond. Water is separated from the tailings by a filtering process through a gravel dike located at the upper end of the impoundment.

4.2 MAINTENANCE OF DAM

The embankment is currently being enlarged to provide additional tailings storage capacity, and, therefore, maintenance of the dam is not strictly practiced. Sand and gravel materials are being dumped in the upstream and downstream directions.

4.3 MAINTENANCE OF OPERATING FACILITIES

There are no operating facilities at this dam. Not applicable.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

Information available to the inspection team indicates that there is no warning system for this dam.

4.5 EVALUATION

The behavior of the dam should be monitored periodically to observe any indications of instability, such as cracks in the dam, sloughing, sudden settlement, erosion of the dam or spillway, or an increase in the volume or turbidity of emerging seepage.

SECTION 5 - HYDRAULIC AND HYDROLOGIC ANALYSES

5.1 EVALUATION OF FEATURES

a. Design Data. The significant dimensions of the dam and spillway are presented in Section 1 - Project Information and in the accompanying field survey drawings, Plates 3 through 5. The available hydrologic and hydraulic design information is limited, as discussed in Section 2 - Engineering Data.

For this evaluation, the watershed drainage area, stream lengths, and reservoir areas were obtained from the 1960, 7-1/2-minute, USGS Vineland, Missouri, Quadrangle, a 20-foot contour interval topographic map. The soil group for this watershed is classified as Clarksville Gravelly Loam, equivalent to a hydrologic soil group B classification, which has a moderate rate of water transmission.

The watershed above the impoundment consists of about 90 percent woodland cover and 10 percent exposed areas. This was determined from field observations and aerial photographs of the project area. The estimated curve numbers are CN 60 for antecedent moisture condition (AMC) II condition, and CN 78 for AMC III condition. Other pertinent data such as basin lag times, unit hydrograph, and probable maximum precipitation are presented in Appendix A.

Two spillway cross-sections were surveyed near the spillway entrance. Channel geometry indicated that the spillway discharge rating curve can be better approximated by using the weir flow-formula instead of uniform flow or critical flow formulae. About 120 feet downstream from the entrance, the spillway channel becomes steeper, and supercritical flow conditions may occur. Computations of the spillway discharge rating curve and the discharge rating curve for flows over the dam crest were made by the weir flow formula, assuming weir coefficients of $C = 2.7$ for the spillway and $C = 3.0$ for the dam crest. The combined discharge rating curve is shown in Appendix A under the input data listing as Y4 and Y5 cards. The reservoir area-capacity and other pertinent data are also in Appendix A in the computer printout.

b. Experience Data. No recorded rainfall, runoff or other experience data are available. Reportedly, the tailings dam has been overtopped once (see letter by J. H. Williams, dated 18 December 1975, in Appendix B).

c. Visual Observations. An open channel spillway is located on the left abutment. Specific information on the visual observations is presented in Section 3 - Visual Inspection.

d. Overtopping Potential. The 100-year flood, probable maximum flood (PMF), and floods expressed as a percent of the PMF were computed and routed through the reservoir and spillway. The PMF is defined as the hypothetical flood event that would result from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible at a particular location or region. The Modified Puls Method of spillway routing was employed. For all spillway flood routings, the level of the reservoir surface was set at the spillway crest elevation at the start of the floods. In the spillway routing, it was assumed that erosion of the earth channel and the spillway section through the embankment will not occur as flood discharges increase; therefore, the spillway discharge rating curve was computed for a specific cross-section and configuration. Results of the overtopping analyses indicate that the spillway is able to pass the 100-year flood. Routing studies indicate that the spillway can also pass about 85 percent of the PMF without overtopping the embankment; however, at 85 percent PMF, the peak spillway outflow is about 690 cfs with a flow depth of 5.0 feet and a flow velocity of about 6 feet per second. High discharge velocities such as those at 85 percent PMF peak outflow could cause significant erosion of the spillway channel or the embankment section.

A major consideration in evaluating the safety of the dam is assessing the potential for overtopping and the subsequent failure of the embankment as a result of erosion. Since the spillway is composed of erodible materials, high velocity discharges through the spillway will lead to erosion of the spillway and embankment even if the dam is not overtopped. Based on the Corps of Engineers Manual EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", the maximum permissible velocity for the materials found in the spillway and the embankment section is about 4 feet per second. Using this as a criterion, it was estimated that the spillway can pass the 30 percent PMF without significant erosion. The 30 percent PMF spillway routed outflow is about 165 cfs with a flow depth of 2.2 feet and velocity of about 4 feet per second. Thus, for determining the erosion potential of the spillway, flows above 4 feet per second and depths higher than 2.2 feet are considered to produce the effects of embankment failure.

Results of the overtopping analyses are reported in Appendix A and are summarized on the following page.

<u>Flood</u>	<u>Peak Inflow (cfs)</u>	<u>Peak Outflow (cfs)</u>	<u>Max Res WS Elev (ft)</u>	<u>Spillway Flow Depth (ft)</u>	<u>Spillway Flow Velocity (ft/sec)</u>	<u>Duration Spillway Vel. Over 4 ft/sec (hrs)</u>
25% PMF	727	123	702.0	1.9	3.7	-
50% PMF	1453	324	703.6	3.3*	4.9*	5.3
75% PMF	2180	580	705.0	4.6*	5.8*	8.0
90% PMF	2616	777	705.7**	5.4**	6.2**	9.2
PMF	2906	967	706.1**	5.5**	6.3**	9.8

* These flow depths and velocities are considered to produce the effects of significant erosion.

** Dam overtopped (Minimum Dam Crest Elev. = 705.5 feet).

Note: Reservoir water surface elevations include the velocity heads corresponding to the velocities computed at the spillway control section.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Conditions that may adversely affect the structural stability of the dam are discussed in Section 3.

b. Design and Construction Data. No design or construction data pertaining to the structural stability of the dam were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and lack of this information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record.

c. Operating Records. No appurtenant structures requiring operation exist at this dam and no records were located.

d. Post-Construction Changes. The dam is currently being raised. Not applicable.

e. Seismic Stability. The dam is located in Seismic Zone 2, as defined in the Uniform Building Code. Because of the large height of the dam and the soft saturated clay foundation soil, there appears to be a potential for instability caused by ground shaking during earthquakes. Some ravelling of the gravels could also occur during seismic shaking because the downstream slope is at or near the natural angle of repose. Crest settlement could also occur because the gravels are in a loose state.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. There are several deficiencies that should be corrected. (1) No erosion protection has been provided in the spillway channel. Since the spillway channel terminates on the left abutment hillside above the natural stream channel, discharge through the spillway could erode the soil downstream of the dam. (2) The discharge capacity of the spillway was computed to be inadequate to pass 50 percent of the Probable Maximum Flood (PMF) without significant erosion of the spillway and dam. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. The "Recommended Guidelines for Safety Inspection of Dams" specify that the spillway design flood for this dam should be the PMF. (3) The seepage and soft soil conditions on the left abutment at the downstream toe of the embankment could adversely affect the stability of the dam. (4) Seepage and stability analyses were not available, and they should be made a matter of record.

b. Adequacy of Information. No detailed design or construction data were available. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, and this lack of data is considered a deficiency.

Results of the hydrologic studies could be changed if larger scale topographic maps with smaller contour intervals were used. The only available topographic map is the 7.5-minute, 1:24,000 scale, 20-foot contour interval USGS quadrangle. All measurements made on this map, such as drainage area, stream lengths, river slopes, and reservoir area-capacity data are insufficient in details, but the map suffices for the Phase I inspection. The use of the USGS quadrangle for the hydrologic studies results in an approximate evaluation of the spillway flood discharge capacity.

c. Urgency. The Phase I inspection indicated apparent deficiencies in the condition of the dam and spillway. Seepage and stability analyses and measures to increase the spillway capacity and provide the spillway with adequate erosion protection should be given priority.

d. Necessity for Phase II. No Phase II investigation is recommended; however, additional investigations are recommended as outlined in Section 7.2.c.

7.2 REMEDIAL MEASURES

The following remedial measures are recommended:

a. Adequate erosion protection should be provided on the spillway channel bottom and side slopes. Erosion protection should also be provided on the upstream face of the dam adjacent to the spillway. The erosion protection should be adequate to withstand the peak discharge velocity resulting from the PMF. The spillway channel should be extended to the natural drainage channel and a sufficient distance downstream so that any discharge will not undercut the toe of the dam or its foundation.

b. The existing spillway capacity was calculated to be adequate to pass 30 percent of the PMF without significant erosion of the spillway and without overtopping the dam. To comply with the Guidelines for a dam of this size and hazard potential, the spillway should be constructed and/or the freeboard increased so that the PMF can be passed without overtopping the dam crest and without significant erosion of the spillway and embankment.

c. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of tailings dams. The necessary data for these analyses would be obtained from additional investigations. The investigations should consist of subsurface exploration and soil sampling and a laboratory testing program to obtain the necessary engineering parameters of the dam and foundation materials. These parameters should be used in an engineering study to evaluate the stability of the dam. The embankment is a relatively porous granular structure above the tailings surface. If the impoundment water level were to rise above the tailings surface, there could be significant seepage through the embankment which could adversely affect the stability of the dam. Included in these analyses, therefore, seepage and stability computations should also be performed with the reservoir water surface set at the top of the dam for the maximum planned height of the embankment. Concurrent with the exploratory work, groundwater monitoring wells should be installed in the drill holes to obtain water level data, which would be used in the stability studies. Based on the results of the stability studies, remedial measures may be necessary. Remedial work should be done under the direction of an engineer experienced in tailings dam design and construction.

d. An inspection and maintenance program should be initiated. Periodic inspections should be made by qualified personnel to observe the performance of the dam and spillway. Observations should include indications of instability, such as cracks in the embankment, sloughing, erosion, sudden settlement, or an increase in the volume or turbidity of the seepage areas. Records should be kept of these inspections and of any corrective maintenance performed at the dam and spillway.

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

The hydrologic and hydraulic analyses were accomplished by using the computer program "Flood Hydrograph Package, HEC-1, Dam Safety Investigations Version, July 1978". This program was developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The criteria and methodology used are briefly discussed below:

- Probable Maximum Precipitation (PMP) - The 24-hour PMP was obtained from Hydrometeorological Report No. 33. The 6-hour and the 1-hour depth-duration distributions followed Corps of Engineers EM 1110-2-1411 criteria.
- 100-year and/or 10-year storms - The 24-hour storm amounts and distributions were supplied by Corps of Engineers, St. Louis District, Missouri.
- Unit Hydrograph - The Soil Conservation Service (SCS) curve-linear unit hydrograph method was used. Basin lag time was computed by using the SCS Curve Number Method and equation.
- Hydrologic Soil Group, Antecedent Moisture Condition (AMC) and Curve Number (CN) - The predominant hydrologic soil group for the watershed was obtained from an agricultural soil classification map prepared by the University of Missouri Agricultural Experiment Station. For the PMF and floods expressed as a percent of PMF, AMC III conditions were used. For the 100-year and/or 10-year floods, AMC II conditions were assumed. Watershed CN was estimated from field observations and from aerial photos.
- Reservoir Area-Capacity - Areas were measured from U.S.G.S. topographic maps. Reservoir elevations and corresponding surface areas were input in the computer program, which determined the reservoir capacities by the Conic Method.
- Reservoir and Spillway Flood Routing - The Modified Puls Method was used for all flood routing through spillway and dam overtopping analyses.

The following pages present the input data listing, the computer program version and its last modification date, together with pertinent computer printouts of results. Definitions of all input and output variable names are presented in the computer program "Users Manual", September 1978, and are not explained herein.

[illegible]

Figure 1. The effect of the concentration of the polymer on the gelation time of the polymer solution. The concentration of the polymer was 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.0, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 6.0, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8.0, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9.0, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9, 10.0, 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 10.9, 11.0, 11.1, 11.2, 11.3, 11.4, 11.5, 11.6, 11.7, 11.8, 11.9, 12.0, 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 12.7, 12.8, 12.9, 13.0, 13.1, 13.2, 13.3, 13.4, 13.5, 13.6, 13.7, 13.8, 13.9, 14.0, 14.1, 14.2, 14.3, 14.4, 14.5, 14.6, 14.7, 14.8, 14.9, 15.0, 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8, 15.9, 16.0, 16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.8, 16.9, 17.0, 17.1, 17.2, 17.3, 17.4, 17.5, 17.6, 17.7, 17.8, 17.9, 18.0, 18.1, 18.2, 18.3, 18.4, 18.5, 18.6, 18.7, 18.8, 18.9, 19.0, 19.1, 19.2, 19.3, 19.4, 19.5, 19.6, 19.7, 19.8, 19.9, 20.0, 20.1, 20.2, 20.3, 20.4, 20.5, 20.6, 20.7, 20.8, 20.9, 21.0, 21.1, 21.2, 21.3, 21.4, 21.5, 21.6, 21.7, 21.8, 21.9, 22.0, 22.1, 22.2, 22.3, 22.4, 22.5, 22.6, 22.7, 22.8, 22.9, 23.0, 23.1, 23.2, 23.3, 23.4, 23.5, 23.6, 23.7, 23.8, 23.9, 24.0, 24.1, 24.2, 24.3, 24.4, 24.5, 24.6, 24.7, 24.8, 24.9, 25.0, 25.1, 25.2, 25.3, 25.4, 25.5, 25.6, 25.7, 25.8, 25.9, 26.0, 26.1, 26.2, 26.3, 26.4, 26.5, 26.6, 26.7, 26.8, 26.9, 27.0, 27.1, 27.2, 27.3, 27.4, 27.5, 27.6, 27.7, 27.8, 27.9, 28.0, 28.1, 28.2, 28.3, 28.4, 28.5, 28.6, 28.7, 28.8, 28.9, 29.0, 29.1, 29.2, 29.3, 29.4, 29.5, 29.6, 29.7, 29.8, 29.9, 30.0, 30.1, 30.2, 30.3, 30.4, 30.5, 30.6, 30.7, 30.8, 30.9, 31.0, 31.1, 31.2, 31.3, 31.4, 31.5, 31.6, 31.7, 31.8, 31.9, 32.0, 32.1, 32.2, 32.3, 32.4, 32.5, 32.6, 32.7, 32.8, 32.9, 33.0, 33.1, 33.2, 33.3, 33.4, 33.5, 33.6, 33.7, 33.8, 33.9, 34.0, 34.1, 34.2, 34.3, 34.4, 34.5, 34.6, 34.7, 34.8, 34.9, 35.0, 35.1, 35.2, 35.3, 35.4, 35.5, 35.6, 35.7, 35.8, 35.9, 36.0, 36.1, 36.2, 36.3, 36.4, 36.5, 36.6, 36.7, 36.8, 36.9, 37.0, 37.1, 37.2, 37.3, 37.4, 37.5, 37.6, 37.7, 37.8, 37.9, 38.0, 38.1, 38.2, 38.3, 38.4, 38.5, 38.6, 38.7, 38.8, 38.9, 39.0, 39.1, 39.2, 39.3, 39.4, 39.5, 39.6, 39.7, 39.8, 39.9, 40.0, 40.1, 40.2, 40.3, 40.4, 40.5, 40.6, 40.7, 40.8, 40.9, 41.0, 41.1, 41.2, 41.3, 41.4, 41.5, 41.6, 41.7, 41.8, 41.9, 42.0, 42.1, 42.2, 42.3, 42.4, 42.5, 42.6, 42.7, 42.8, 42.9, 43.0, 43.1, 43.2, 43.3, 43.4, 43.5, 43.6, 43.7, 43.8, 43.9, 44.0, 44.1, 44.2, 44.3, 44.4, 44.5, 44.6, 44.7, 44.8, 44.9, 45.0, 45.1, 45.2, 45.3, 45.4, 45.5, 45.6, 45.7, 45.8, 45.9, 46.0, 46.1, 46.2, 46.3, 46.4, 46.5, 46.6, 46.7, 46.8, 46.9, 47.0, 47.1, 47.2, 47.3, 47.4, 47.5, 47.6, 47.7, 47.8, 47.9, 48.0, 48.1, 48.2, 48.3, 48.4, 48.5, 48.6, 48.7, 48.8, 48.9, 49.0, 49.1, 49.2, 49.3, 49.4, 49.5, 49.6, 49.7, 49.8, 49.9, 50.0, 50.1, 50.2, 50.3, 50.4, 50.5, 50.6, 50.7, 50.8, 50.9, 51.0, 51.1, 51.2, 51.3, 51.4, 51.5, 51.6, 51.7, 51.8, 51.9, 52.0, 52.1, 52.2, 52.3, 52.4, 52.5, 52.6, 52.7, 52.8, 52.9, 53.0, 53.1, 53.2, 53.3, 53.4, 53.5, 53.6, 53.7, 53.8, 53.9, 54.0, 54.1, 54.2, 54.3, 54.4, 54.5, 54.6, 54.7, 54.8, 54.9, 55.0, 55.1, 55.2, 55.3, 55.4, 55.5, 55.6, 55.7, 55.8, 55.9, 56.0, 56.1, 56.2, 56.3, 56.4, 56.5, 56.6, 56.7, 56.8, 56.9, 57.0, 57.1, 57.2, 57.3, 57.4, 57.5, 57.6, 57.7, 57.8, 57.9, 58.0, 58.1, 58.2, 58.3, 58.4, 58.5, 58.6, 58.7, 58.8, 58.9, 59.0, 59.1, 59.2, 59.3, 59.4, 59.5, 59.6, 59.7, 59.8, 59.9, 60.0, 60.1, 60.2, 60.3, 60.4, 60.5, 60.6, 60.7, 60.8, 60.9, 61.0, 61.1, 61.2, 61.3, 61.4, 61.5, 61.6, 61.7, 61.8, 61.9, 62.0, 62.1, 62.2, 62.3, 62.4, 62.5, 62.6, 62.7, 62.8, 62.9, 63.0, 63.1, 63.2, 63.3, 63.4, 63.5, 63.6, 63.7, 63.8, 63.9, 64.0, 64.1, 64.2, 64.3, 64.4, 64.5, 64.6, 64.7, 64.8, 64.9, 65.0, 65.1, 65.2, 65.3, 65.4, 65.5, 65.6, 65.7, 65.8, 65.9, 66.0, 66.1, 66.2, 66.3, 66.4, 66.5, 66.6, 66.7, 66.8, 66.9, 67.0, 67.1, 67.2, 67.3, 67.4, 67.5, 67.6, 67.7, 67.8, 67.9, 68.0, 68.1, 68.2, 68.3, 68.4, 68.5, 68.6, 68.7, 68.8, 68.9, 69.0, 69.1, 69.2, 69.3, 69.4,

 PLOU HYDROGRAPH PACKAGE (HBC-1)
 DAM SAFETY VERSION JULY 1976
 LAST MODIFICATION 26 FEB 79

R/N DATE 79/05/08
 TIME 04.57.40.

DRESSER NO. 10 TAILINGS DAM -- NO NO. 31153
 HEC-1 PHASE I DAM SAFETY INVESTIGATIONS
 RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION									
NQ	N4P	NMIN	JDAY	IHW	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	2	0
	JUPER	NMT	LROPT	TRACE					
	5	0	0	0					

MULTI-PLAN ANALYSES TO BE PERFORMED

NPLANE 1 NMTIO= 5 LRTIO= 1

RTIOS= .25 .50 .75 .90 1.00

***** SUB-AREA RUNOFF COMPUTATION *****
 ISTAQ ICOMP IECN ITAPE JPLT JPRT INAME ISTAGE IAUO
 INFLOW 0 0 0 0 0 0 0 0 0

HYDROGRAPH DATA
 IHTDG IUNG TAREA SNAP TRSDA TRSPC RATIO ISNOW ISAME LOCAL
 1 2 .29 0.00 .29 1.00 0.00 0 1 0

PRECIP DATA

SPFE PMS R6 R12 R24 R48 R72 R96
 0.00 25.50 102.00 120.00 130.00 0.00 0.00 0.00

LOSS DATA

LROPT STRKR DLTKR RTIOL EMAIN STMAS RTIOL STRTL CNSTL ALSMX RTIMP
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CURVE NO = -78.00 WETNESS = -1.00 EFFECT CM = 78.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .26

RECESSION DATA

STRICE -10.00 ORCSNE -.10 RTIOW= 2.50

UNIT HYDROGRAPH IN END OF PERIOD ORIGINATES, ICE 0.00 HOURS, LAGE .26 VOL= 1.00 40.
 77. 261. 434. 372. 238. 148. 97. 62.
 25. 16. 10. 7. 4. 3. 2. 0.

MO.DA MP.MN PERIOD RAIN EXCS LOSS COMP Q MO.DA MP.MN PERIOD RAIN EXCS LOSS COMP Q

1.01	5.10	60	.01	.00	.01	10.	1.01	17.00	204	30	.30	.00	6.4.
1.01	5.15	61	.01	.00	.01	10.	1.01	17.05	205	.24	.24	.00	6.4.
1.01	5.20	62	.01	.00	.01	10.	1.01	17.10	206	.24	.24	.00	6.4.
1.01	5.25	63	.01	.00	.01	11.	1.01	17.15	207	.24	.24	.00	6.4.
1.01	5.30	64	.01	.00	.01	11.	1.01	17.20	208	.24	.24	.00	6.4.
1.01	5.35	65	.01	.00	.01	11.	1.01	17.25	209	.24	.24	.00	6.4.
1.01	5.40	66	.01	.00	.01	11.	1.01	17.30	210	.24	.24	.00	6.4.
1.01	5.45	67	.01	.00	.01	11.	1.01	17.35	211	.24	.24	.00	6.4.
1.01	5.50	68	.01	.00	.01	12.	1.01	17.40	212	.24	.24	.00	6.4.
1.01	5.55	69	.01	.00	.01	12.	1.01	17.45	213	.24	.24	.00	6.4.
1.01	5.60	70	.01	.00	.01	12.	1.01	17.50	214	.24	.24	.00	6.4.
1.01	5.65	71	.01	.00	.01	12.	1.01	17.55	215	.24	.24	.00	6.4.
1.01	5.70	72	.01	.00	.01	12.	1.01	18.00	216	.24	.24	.00	6.4.
1.01	5.75	73	.00	.03	.04	14.	1.01	18.05	217	.02	.02	.00	6.4.
1.01	5.80	74	.00	.03	.04	20.	1.01	18.10	218	.02	.02	.00	6.4.
1.01	5.85	75	.00	.03	.03	30.	1.01	18.15	219	.02	.02	.00	6.4.
1.01	5.90	76	.00	.03	.03	40.	1.01	18.20	220	.02	.02	.00	6.4.
1.01	5.95	77	.00	.03	.03	50.	1.01	18.25	221	.02	.02	.00	6.4.
1.01	6.00	78	.00	.03	.03	57.	1.01	18.30	222	.02	.02	.00	6.4.
1.01	6.05	79	.00	.03	.03	62.	1.01	18.35	223	.02	.02	.00	6.4.
1.01	6.10	80	.00	.03	.03	62.	1.01	18.40	224	.02	.02	.00	6.4.
1.01	6.15	81	.00	.03	.03	70.	1.01	18.45	225	.02	.02	.00	6.4.
1.01	6.20	82	.00	.03	.03	74.	1.01	18.50	226	.02	.02	.00	6.4.
1.01	6.25	83	.00	.03	.03	76.	1.01	18.55	227	.02	.02	.00	6.4.
1.01	6.30	84	.00	.03	.03	79.	1.01	19.00	228	.02	.02	.00	6.4.
1.01	6.35	85	.00	.04	.02	81.	1.01	19.05	229	.02	.02	.00	6.4.
1.01	6.40	86	.00	.04	.02	83.	1.01	19.10	230	.02	.02	.00	6.4.
1.01	6.45	87	.00	.04	.02	85.	1.01	19.15	231	.02	.02	.00	6.4.
1.01	6.50	88	.00	.04	.02	87.	1.01	19.20	232	.02	.02	.00	6.4.
1.01	6.55	89	.00	.04	.02	89.	1.01	19.25	233	.02	.02	.00	6.4.
1.01	6.60	90	.00	.04	.02	91.	1.01	19.30	234	.02	.02	.00	6.4.
1.01	6.65	91	.00	.04	.02	92.	1.01	19.35	235	.02	.02	.00	6.4.
1.01	6.70	92	.00	.04	.02	94.	1.01	19.40	236	.02	.02	.00	6.4.
1.01	6.75	93	.00	.04	.02	94.	1.01	19.45	237	.02	.02	.00	6.4.
1.01	6.80	94	.00	.04	.02	97.	1.01	19.50	238	.02	.02	.00	6.4.
1.01	6.85	95	.00	.05	.02	98.	1.01	19.55	239	.02	.02	.00	6.4.
1.01	6.90	96	.00	.05	.02	99.	1.01	20.00	240	.02	.02	.00	6.4.
1.01	6.95	97	.00	.05	.02	101.	1.01	20.05	241	.02	.02	.00	6.4.
1.01	7.00	98	.00	.05	.02	102.	1.01	20.10	242	.02	.02	.00	6.4.
1.01	7.05	99	.00	.05	.02	103.	1.01	20.15	243	.02	.02	.00	6.4.
1.01	7.10	100	.00	.05	.02	104.	1.01	20.20	244	.02	.02	.00	6.4.
1.01	7.15	101	.00	.05	.02	105.	1.01	20.25	245	.02	.02	.00	6.4.
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1.01	12.00	144	.06	.35	.01	237.	1.02	0.00	288	.02	.02	.02	.02

SUM 53.15 30.02 2.53 70249.
(842.3) (778.3) (64.3) (1989.23)

PEAK 2906.
CFS
CMS
14-CHES
MM
AC-FT
THOUS CU M

6-HOUR 787.
22.
25.07
636.79
390.
481.

24-HOUR 244.
7.
31.07
789.08
484.
596.

72-HOUR 244.
7.
31.07
789.08
484.
596.

TOTAL VOLUME
70212.
1986.
31.07
789.08
484.
596.

HYDROGRAPH ROUTING									
ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO	
LAKE	I	0	0	0	0	0	0	0	
QLOSS	CLOSS	AVG	IRCS	ISAME	IOPT	IPMP	LSTR		
0.0	0.000	0.00	1	1	0	0	0		
NSTPS	NSTOL	LAG	AMSKA	X	TSK	STORA	ISPRAT		
1	0	0	0.000	0.000	0.000	-700.	-1		
STAGE	700.00	701.10	702.20	703.30	704.40	705.50	706.10	707.20	708.30
FLOW	0.00	45.00	135.00	270.00	460.00	695.00	940.00	2060.00	3945.00
									6430.00

APPENDIX B
INFORMATION SUPPLIED BY OTHERS

ENGINEERING GEOLOGIC REPORT ON DRESSER NO. 10 BARITE POND

Jefferson County, Mo.

LOCATION: Center north $\frac{1}{2}$, Sec. 17, T. 38 N., R. 4 E., Vineland Quadrangle

GEOLOGIC SETTING:

The dam has been constructed on weathered Potosi dolomite. The material used for the dam consists of red clay mixed with stone that has been borrowed from deposits of Potosi residuum. Bedrock is exposed on the left abutment where a spillway has been constructed.

The dam was suffering from slides on the interior slope. MESA recommended adding red clay to that interior front slope in order to stabilize these slides. However, the customary mine procedure is to deposit gravels and other materials on the front slope of the dam allowing these to fall and slide into the slime pond and on top of liquid mud. This, there is no stability to the front slope of the structure. The only stability is that of the original starter dam and the compacted center portion of the gravel dam as it is carried upward to higher from the original starter dam.

The starter dam is leaking severely, particularly in the lower 20 feet. Leakage is more severe on the left portion of the starter dam. In addition, water is flowing from the Potosi dolomite near the lower right toe of the dam. This flow is in the streambed, however, and some 20 feet downstream of the downstream toe of the dam. This was reported to be a spring, however, the geologic setting and temperature indicates that the water is primarily from water in the upstream portion of the dam. Since the water is clear it has yet to be affected by the muds that are near the main portion of the dam.

RECOMMENDATIONS:

It appears essential that a wide well compacted berm of large gravelly material be placed at the downstream toe of the dam. This berm could be placed over the stream provided that drainage facilities are maintained. This would require that the gravel placed by the spring be free of fines that is silt and clay material.

The dam is seeping badly also at the point of contact between the overlying gravel deposits and the crest of the original starter dam. It is my belief that this seepage is being controlled by the contact of the original starter dam with the gravels, and that this leakage will continue. However, the deposits of mud that are being made along the upstream face of the dam are claimed to have sufficient fines to seal the front slope of the structure. Again, I cannot accept this belief. But rather I believe that leakage gradually ceases as water is eventually drained from the clay and coarser materials that are deposited on the interior face of the dam.

Stability of this structure cannot be achieved unless a well compacted berm of adequate width is placed at the downstream toe of the structure. This berm should consist of bull rock that is large chert fragments up to boulder in size. Once the drainage blanket for this is established, which would include the spring area, the upper portion of the berm could consist of large rock fragments intermixed with clays and silts.

James H. Williams, Chief
Applied Engineering & Urban Geology
Missouri Geological Survey
September 30, 1975

December 18, 1975

Please reply to:
P. O. Box 250
Rolla, MO 65401

Bob Lindholm
Attorney General's Office
Supreme Court Bldg.
Jefferson City, MO 65101

Dear Bob:

The tailings dam, reported overtopped by Bob Blackwell, is Dresser #10 located in SE $\frac{1}{4}$, NE $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 17, T. 38 N., R. 4 E., Jefferson County. This is a dam that has been the point of issue between canoeists on Big River and the bridge constructed by Dresser for access.

I understand that MESA has cited Dresser for operating violations at the #10 site. MESA personnel had expected the dam was overtopped based on evidence that was observed when inspected for structural condition.

I am concerned about this dam and have mentioned my concern to Dresser personnel including Gene Williams and Bob Bevins. This dam apparently has high seepage rates through the compacted dirt used in the starter dam. The back slope of the dam is soft due to this excess seepage. In addition, there is a spring flowing from bedrock just downstream of the dam. I am told that flow in this spring increased as water accumulated in the tailings pond.

I do not believe that a hazard exists to persons downstream as of this moment since construction has, in essence, just begun on the tailings dam. The present dam is no more than 40-45 feet in height; however, the completed structure may be more than 100 feet in height. Therefore, this dam could cover the spring. The foundation might possibly rest on soft soil in the downstream area adjacent to Big Spring area and failure within the structure due to the spring might also occur. Consequently, there is reason for concern relative to safety of personnel as the height of the dam increases with operation of the barite facility. MESA is reviewing some plans submitted by Dresser on this dam. I suspect that their comments will be such that Dresser will not be allowed to continue operation until some of these hazards are corrected.

I just received some historic air photos coverage of Dresser #4. In 1955 only the main or downstream dam existed. At that time, mud tailings

Bob Lindholm
Page 2
December 18, 1975

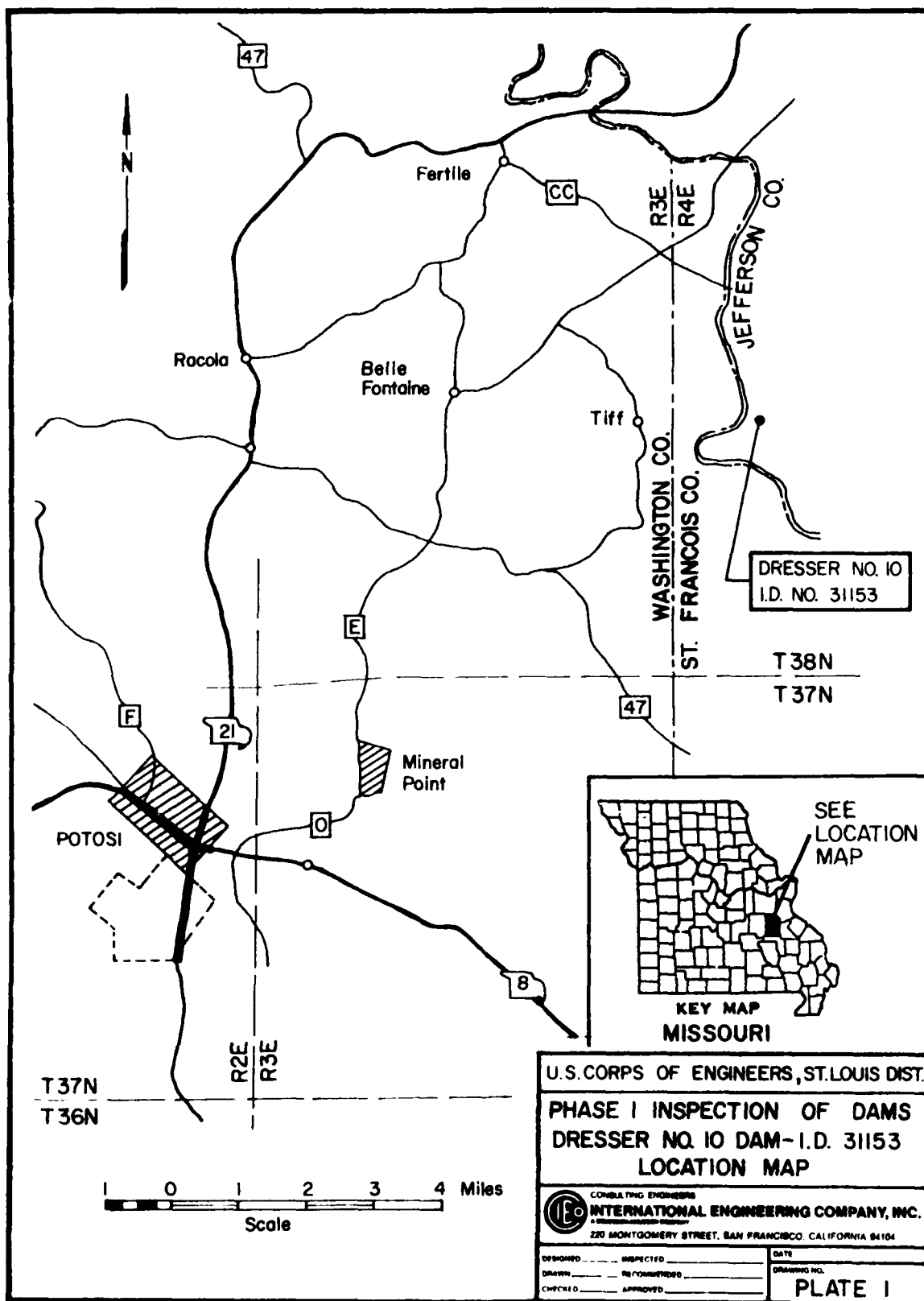
had accumulated upstream beyond the point where the present levee failed in August 1973. The next photo is in 1964. At that time, the tailings pond had the outline as it exists today. The portion of the levee that failed is across the stream channel which had previously been occupied by tailings. One is then faced with the various possible alternatives which include, building the levee on mud, constructing a core trench through the mud, or lowering the level of mud. The last two procedures would have been very difficult to achieve.

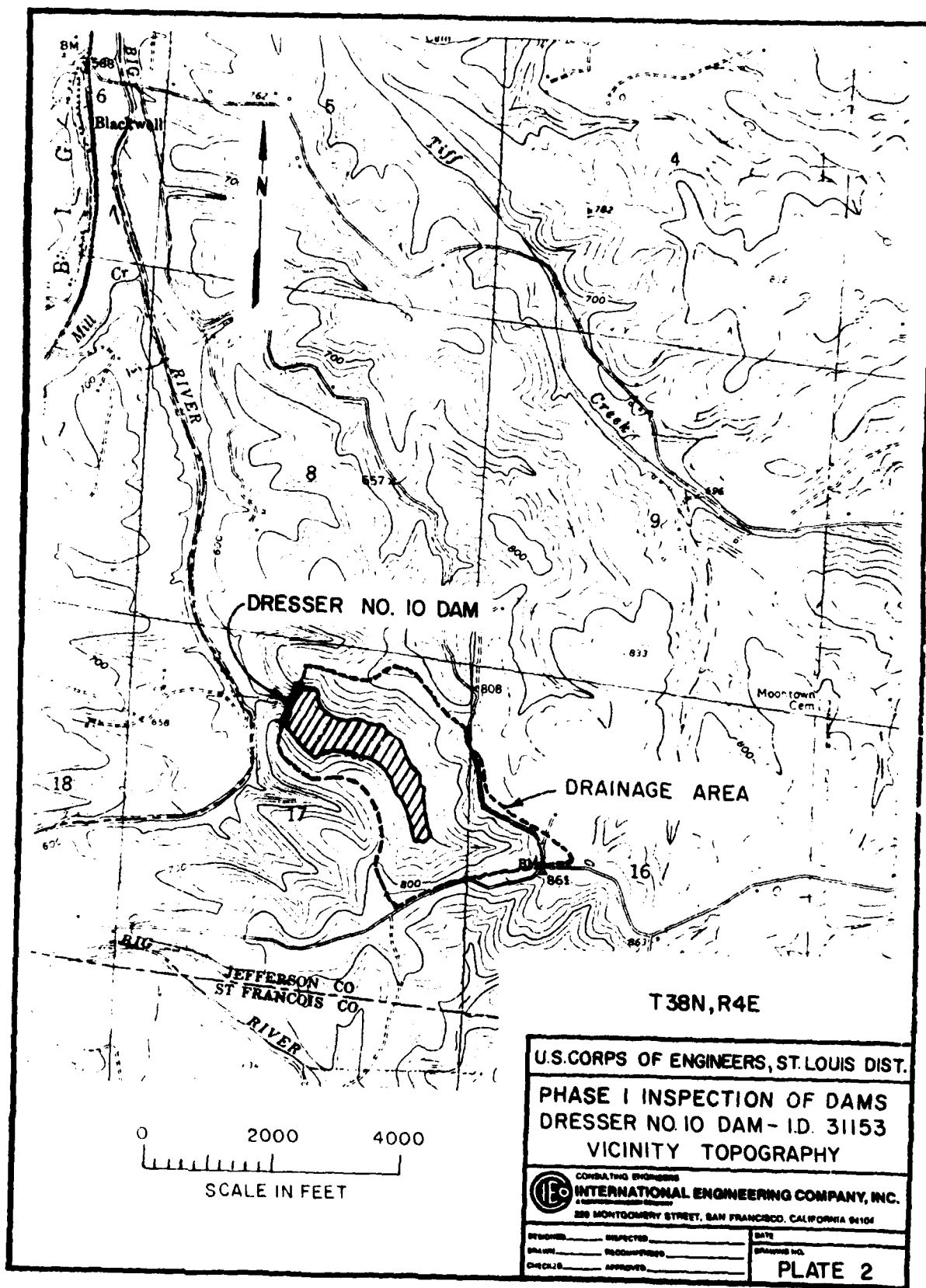
Merry Christmas!

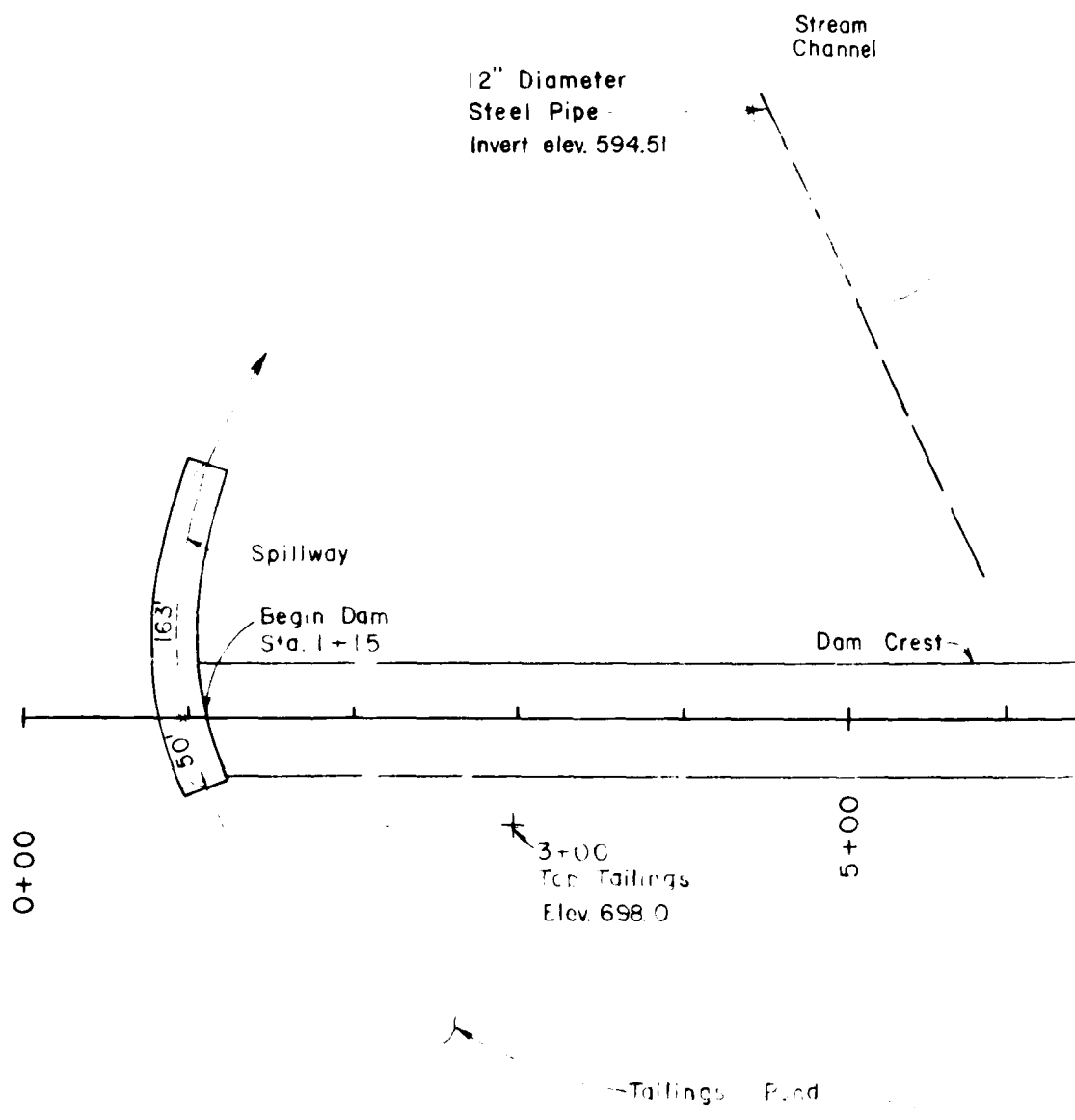
Sincerely yours,

Dr. J. Hadley Williams, Chief
Applied Engineering & Urban Geology
Geology & Land Survey

JHW/dab







Bench Mark RR Spike in 18" White Oak.
70' South and 20' East of Sta. 0+00
Elev. 740.00
Date of Survey: 3/26/79

Stream
Channel

Dam Crest

End Dam
Sta. 8+80

Reag to Mill

5+00

8-00
Tailings
Elev. 7021

10+00

10+40

Tailings
Discharge
from
Mill

DAM I.D. NO. 31153
DRESSER No. 10

PLAN
SCALE IN FEET

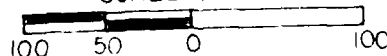
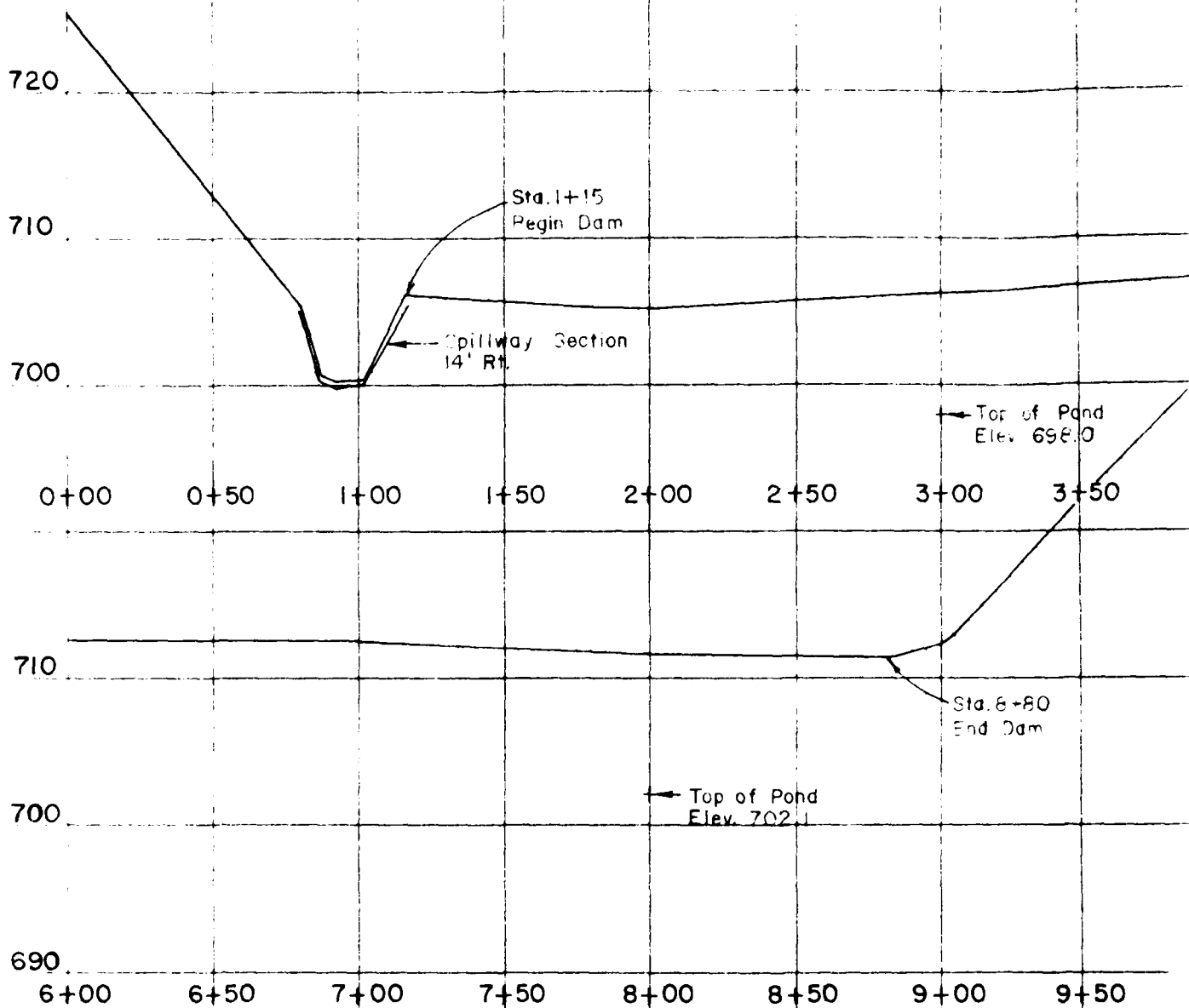
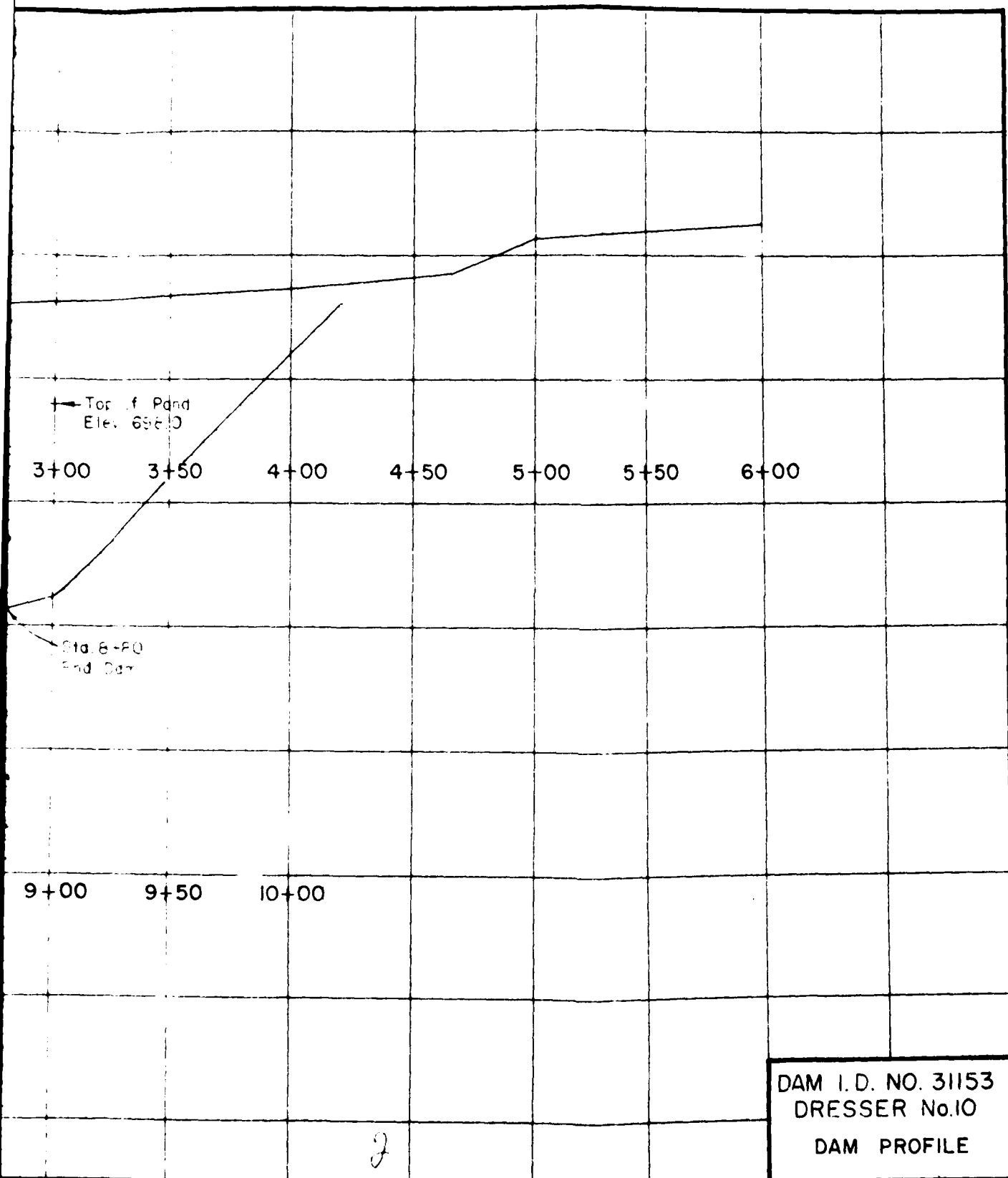
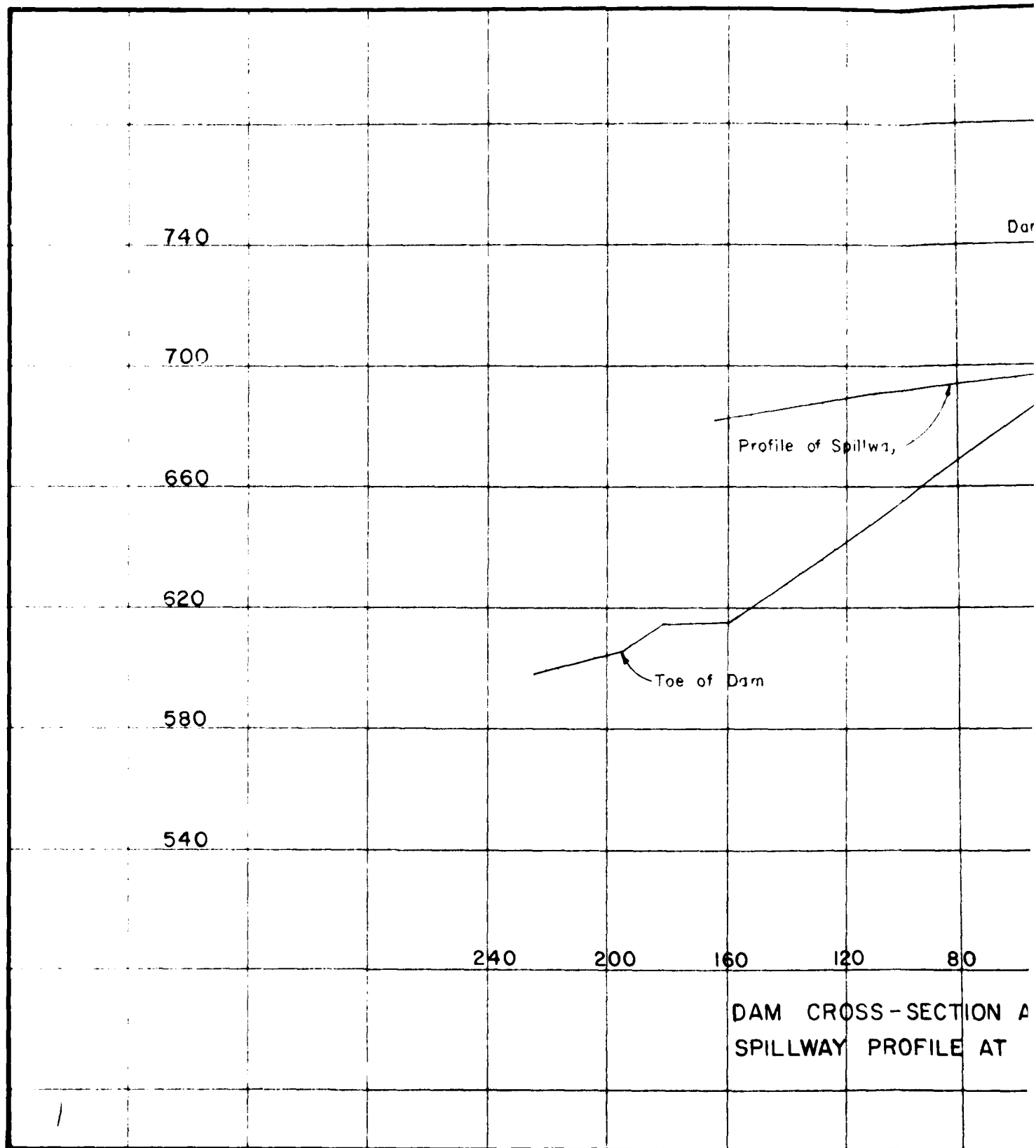


PLATE 3







Dam Crest

Top Tailings
Elev 6992

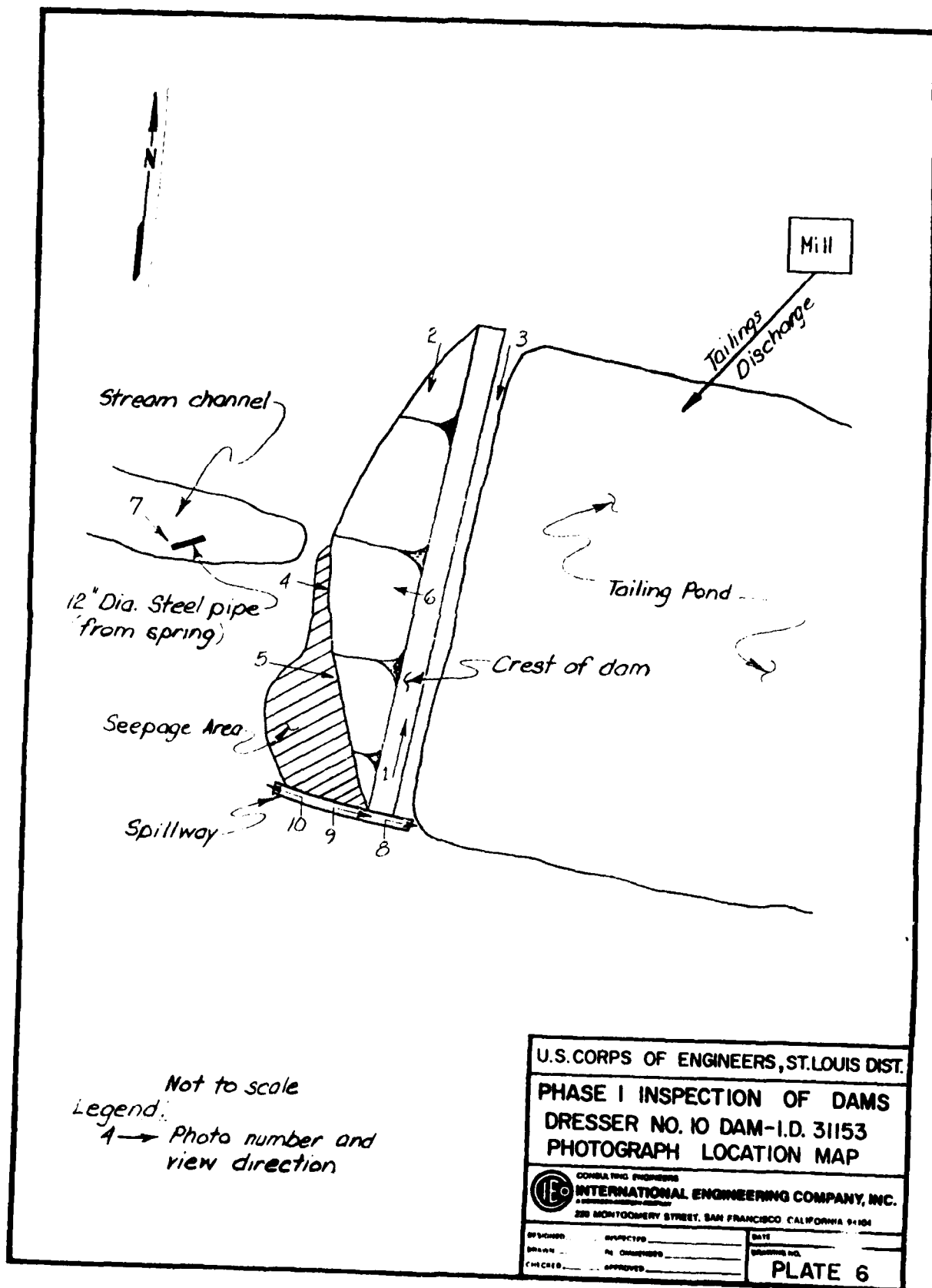
of Spillway,

120 80 40 0 40 80

CROSS-SECTION AT STATION 4+94
WAY PROFILE AT STATION 0+94

DAM I. D. NO. 31153
DRESSER No. 10
Dam Cross-Section
Spillway Profile

PLATE 5



PHOTOGRAPH RECORD

DRESSER NO. 10 DAM - I.D. NO. 31153

Photo No.	Description
1	Downstream face and crest of dam toward right abutment.
2	Downstream face of dam toward left abutment. The uppermost cut is the spillway.
3	Upstream face of dam toward left abutment. Sloughing of gravels caused by the mill discharge which has undercut the face of the dam is apparent in photograph.
4, 5	Seepage and marshy condition at toe of dam.
6	View downstream of dam toward Big River.
7	12-inch diameter steel pipe which conveys discharge from spring beneath the dam.
8	Upstream end of spillway and tailings impoundment.
9	View upstream in spillway channel with dam at left.
10	Downstream end of spillway showing poorly-defined shallow channel.

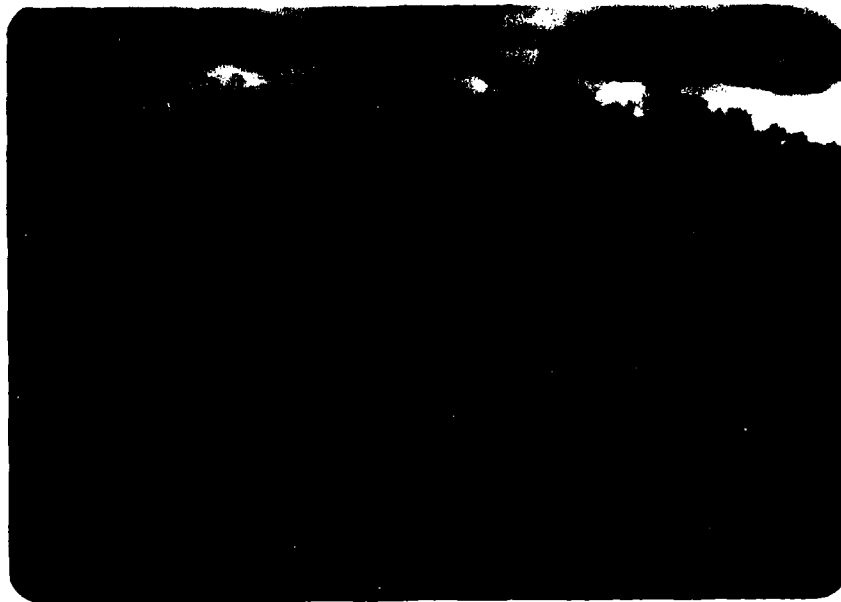
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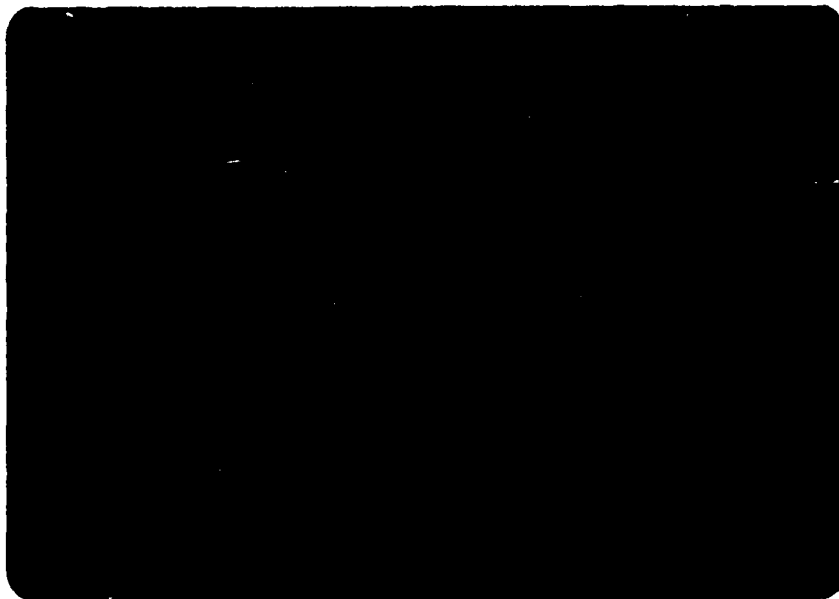
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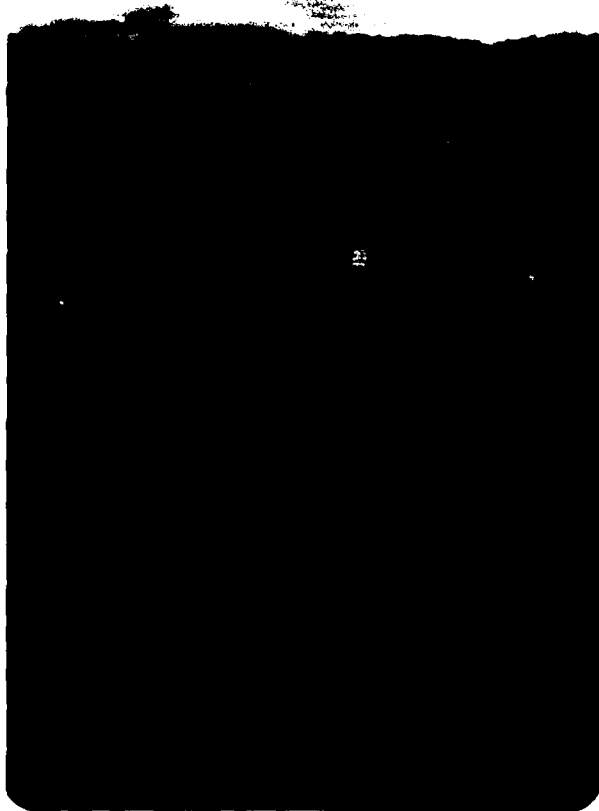


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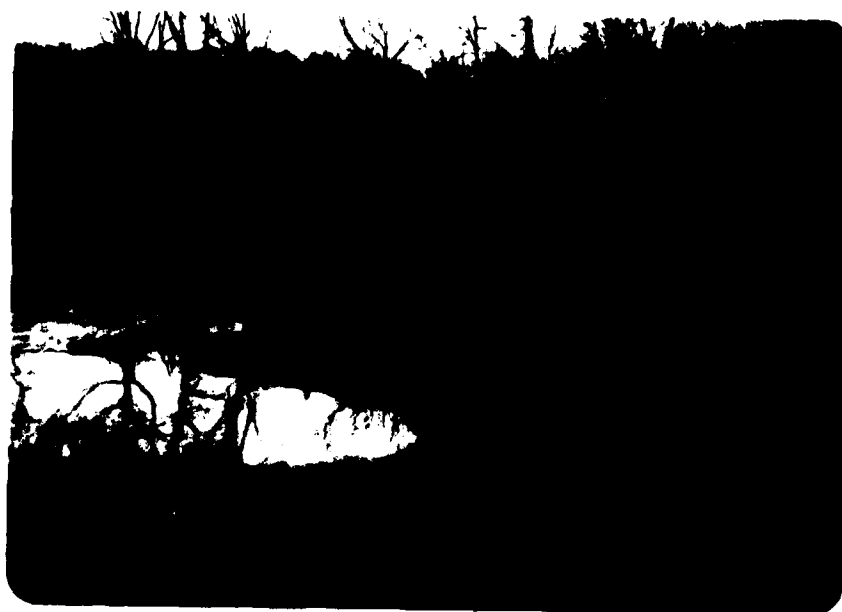


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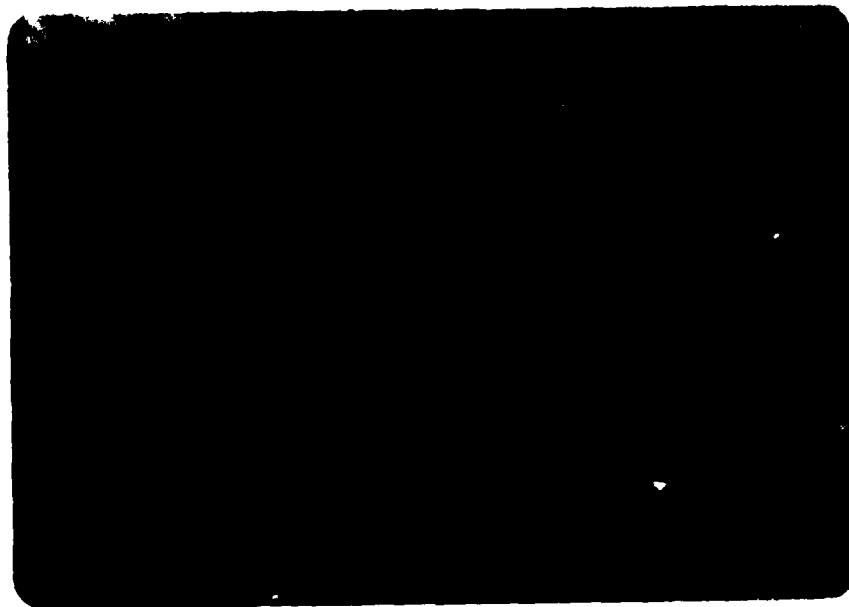
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END

DATE
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11-81

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